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CANADIAN SEED GROWERS' ASSOCIATION

CLASSIFICATION OF CANADIAN SPRING WHEAT VARIETIES

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WITH APPENDIX
PLANT BREEDERS' SERIES No. 1

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The Classification of Canadian Spring Wheat Varieties

By L. H. Newman, *Dominion Cerealist, Ottawa*

FOREWORD

The need for definite and precise information concerning those characters which distinguish wheat varieties is becoming more and more pressing as the number of varieties coming into circulation increases. This need is felt both by the breeder and by those charged with the official inspection of crops for which registration is sought. Perhaps it is felt most at present by the latter, upon whom rests the responsibility of declaring whether official certificates of registration, certifying as to the trueness to type of the varieties inspected, should or should not be issued.

Those who have followed the discussions which have taken place before this body on the occasion of the past three or four annual meetings particularly, will have been impressed with the very evident desire of all concerned to be assured that the propagation of Registered Seed and all that this term implies, is founded upon a sound and sane basis. The chief concern naturally has centered around the production of Elite Stock Seed since this is the essential basis of Registered Seed. Elite Stock Seed has been defined and methods by which it may be produced have been suggested. The association has decreed that this class of seed must be, to all intents, *pure and true to a given type*. Are our Elite Stocks all that the definition requires? This is the question which has been asked and which deserves an answer.

No provision has been made by the association for varieties which are distinctly composite in character since such is considered not only unnecessary but more or less undesirable at present. Possibly some day varieties of a composite nature may be developed which may be worthy of special encouragement and protection, but at present the association is concerned only in the propagation of what are commonly called "Pure-lines" in so far as our common cereals are concerned. Since the term "Pure-line" implies that the distinguishing characters of a pure variety are relatively well defined and prescribed, within the limits of environmental modification, it at once becomes imperative that these characters and their "Modification Range" be thoroughly understood and recorded. Such an understanding of any given "line" requires a very intimate and extensive study thereof under widely different conditions. Obviously those who are actively engaged in plant breeding work at the different institutions throughout Canada are the people who are in the best position to make such a study. Recognizing this fact the association has solicited the active co-operation of these men, even to the extent of taking certain action which has resulted in the organization of what is known officially as a "Plant Breeders' Committee." As chairman of the Cereal Section of this committee, the writer has pleasure in reporting that his committee has endeavoured to do what it could during the past two years not only to determine the purity of Elite Stocks now being propagated but to devise practical methods of producing such stocks. By a happy coincidence the Cereal Division of the Dominion Experimental Farms, which the writer represents, already had initiated certain studies of the various varieties under test

at our numerous and widely scattered branch Farms in order partly to check up on the purity and trueness to type of these varieties, and partly to develop, if possible, a more usable classification and varietal key than was then available. This study included various Elite Stock Seed Stocks submitted to us under number by the secretary of this association, so was admirably suited to provide the sort of information wanted. A brief preliminary report, covering the work of 1924 only, has been published elsewhere.* Parts of this report will be referred to in the present paper in order that the subject may be covered more fully.

As intimated in the above-mentioned report our efforts in the direction of perfecting a classification of our common spring wheats have been based largely upon the monumental work of Clark, Martin and Ball of the United States Department of Agriculture, Washington, D.C.† The general classification prepared by these men would be difficult to excel in many respects, but since many of our Canadian varieties are not included and since some that are may be more minutely described than they have been, an attempt has been made to construct a key which may be more useful for Canadian workers in this field.‡ The work is still far from complete since an undertaking such as this demands not only that large numbers be dealt with but that these be grown under as widely different conditions as possible. Such conditions are provided to perfection by the widely scattered branch Farms of the federal Department of Agriculture, at which places there are being grown the same varieties from the same original seed, in most cases. What we shall say in this paper, concerning the peculiarities of the varieties dealt with, will be based largely upon the behaviour of the latter under the conditions at these Farms.

THE BASIS OF CLASSIFICATION

The construction of a key designed to facilitate the determination of the identity of different varieties must necessarily be based upon certain more or less arbitrary divisions. The first major division between varieties recognized by most taxonomists is on the basis of "Awn development." Thus, they divide all varieties into two main groups viz, *Awned* and *Awnless* groups. Each of these groups is again divided and subdivided on the basis first of Covering of Glume (pubescent or glabrous), Colour of Glume (white or brown) and Colour of Grain (white or red). The Colour of the Stem (white or purple) is taken into consideration in some cases, although this is considered of minor importance owing to the extent to which colour is affected by external conditions. The writer has ventured to give this character a major place in the classification he is endeavouring to develop on account of the extent to which he is able to use it when checking up the purity of varieties grown at different branch Farms throughout Canada. Thus at some Farms in some seasons the purple colour peculiar to some varieties may be scarcely apparent while at other Farms the same varieties, coming from the same lot of seed, may be strongly purple.

AWNS

Varieties classed as Awned are those which have an Awn or "beard" terminating the lemma or flowering glume of all spikelets. Varieties classed as *Awnless* may have short awns terminating the lemmas of the tip spikelets or of spikelets near the tip of the spike. Tip or " apical " awns differ in length, colour,

* See Proceedings of Fifth Annual Meeting of the Western Canada Society of Agronomy, University of Manitoba, Winnipeg, Man., December, 1924.

† Classification of American wheat varieties: Clark, Martin and Ball—U.S. Bull 1074, Washington, D.C.

‡ This key, accompanied by illustrations and detailed monographs will appear later.

FIG. Ia—Normal head of Kitchener. FIG. Ib—Subnormal head of Kitchener.
Note similarity of glumes in both cases.

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FIG. IIa—Normal head of Early Red Fife. FIG. IIb—Subnormal head of Early Red Fife. Note similarity of glumes in both cases.

FIG. III—Marquis—two views.

FIG. IV—Head of Common Red Fife (two views).

number and divergence from the vertical. Under some conditions they may become quite strongly developed while under others they may be relatively inconspicuous. Some varieties are entirely devoid of tip awns irrespective of external conditions. Early Triumph and Supreme are good examples of such varieties.

The colour of awn is sometimes a useful character in distinguishing varieties although not sufficiently constant to be depended upon.

DENSITY OF SPIKE

Three classes or degrees of spike density viz. *lax, mid-dense* and *dense* are recognized by Clark, Martin and Ball and have been adopted in the present work without modification. "Spikes are classed as lax when 10 internodes occupy from 50 to 75 m.m., as mid-dense when 10 internodes occupy from 35 to 60 m.m., and as dense when 10 internodes occupy from 20 to 45 m.m.".

The density of the spike is affected very appreciably by the general development of the plant. Spikes which are abnormally developed, as often is the case along the margins of fields or plots, are likely to be more open or "lax" than are those which have developed normally. Similarly, heads which are sub-normal in development as when borne on late developing tillers are likely to be more dense. It is important, therefore, to note the general development of the plant before taking the density of spike into consideration and even then there is some danger of attaching too much importance to so variable a character, although the latter often may be of very considerable assistance.

SHAPE OF SPIKE OR HEAD

Clark, Martin and Ball define four main types of spike or head as regards shape, viz., *Fusiform, Oblong, Clavate* or "Clubbed" and *illiptical*. While shape of spike varies considerably under different growing conditions, yet this character is of decided value and therefore occupies a prominent place in the Key.

Spikes which are classed as *Clavate* vary most. Varieties such as Kitchener (figs. Ia and Ib) and Early Red Fife, (figs. IIa and IIb), for instance, are placed among the varieties which normally possess clavate spikes yet under certain conditions, as indicated, the full development of the tip of the spike which gives these varieties their characteristic appearance, is lacking (figs. Ib and IIb). In such cases Kitchener might easily pass as Marquis (fig. III) and Early Red Fife as Red Fife (fig. IV) if no other character than shape of spike were available to distinguish them. Fortunately the outer or empty glumes, which latter constitute the outer parts of each floret, afford an effective aid in distinguishing these varieties when shape of spike fails.

The structure of the tip of the spike also may be of great assistance in this connection. Thus in Kitchener, as well as in the Fifes, the internodes of the rachis towards the tip of the spike are shorter and the terminal spikelet normally has at least one more well developed floret, than those varieties which never develop Clavate heads. As a matter of fact it is only when the Kernels within these florets, densely arranged as they are, become properly developed that the head assumes a Clavate or "Clubbed" appearance.

GLUME CHARACTERS

The character of the outer or empty glume has always played a more or less important role since systematists first began to record differences between different forms. This is particularly true as regards covering and colour. Clark, Martin and Ball have also used the width and shape of shoulder and beak of the glume to a considerable extent. These people have distinguished three main

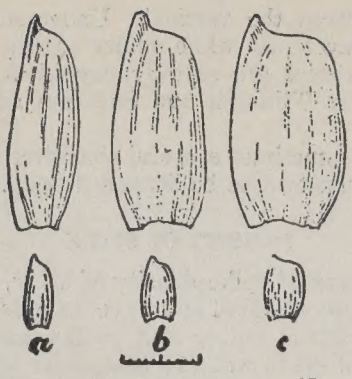

FIG. V—Shoulder widths: *a*, Narrow; *b*, midwide; *c*, wide. (Natural size and enlarged 3 diameters.)

(After Clark, Martin and Ball)

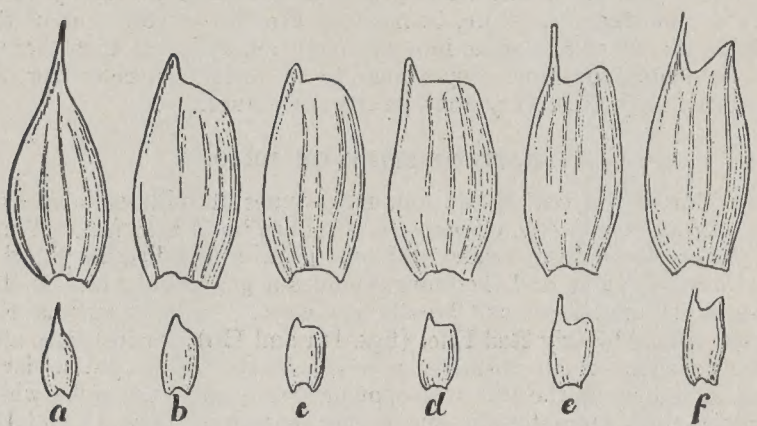

FIG. VI—Shoulder shapes: *a*, Wanting; *b*, oblique; *c*, rounded; *d*, square; *e*, elevated; *f*, apiculate. (Natural size and enlarged 3 diameters.)

(After Clark, Martin and Ball)

FIG. VII—Beak shapes—A, obtuse; B, acute; C, accumate; D, oblong.

(Adapted from Clark, Martin and Ball)

types of glume as regards "width", viz., *Wide, mid-wide* and *narrow* (fig. V). They also have defined six types of shoulder as regards "shape" viz., *wanting, oblique, rounded, square, elevated* and *apiculate* (fig. VI). These terms have been adopted in the present treatment as they seem to meet all essential needs.

The "beak" which is the term applied to the short extension of the keel of the empty glume, has been found quite valuable in the identification of varieties. As a matter of fact the writer has found this character one of the most useful ones in this work, although here again one must be familiar with the degree to which the *shape* of beak particularly, may vary from the normal. The above-mentioned authorities use the terms *obtuse, acute* and *accuminate* in describing the apex of the beak. The writer has found it desirable to add one other term "*oblong*", in order to describe beaks such as those which normally characterize such types as Early Red Fife (fig. VII).

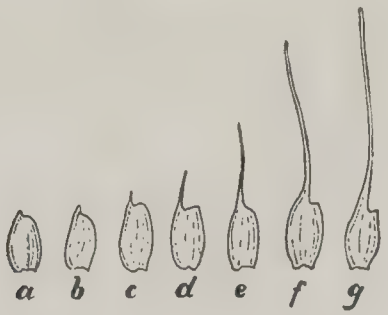

FIG. VIII—Beak lengths, showing seven variations (natural size).
(After Clark, Martin and Ball)

The length of the beak differs quite definitely with the variety. Some varieties, such as Major, possess glumes bearing beaks scarcely .5 m.m. in length, whereas other varieties, such as Kota, may have beaks 20 m.m. long (fig. VIII).

The shape and width of shoulder as well as the length, and to some extent the shape of the beak, varies from the base to the tip of the spike in a fairly progressive manner. It is necessary, therefore always to take the same spikelet counting from the base, infertile spikelets included. The writer, for no very definite reason has taken the spikelet located at the seventh node from the base in connection with these studies.

There is also a difference between the primary and secondary outer glumes, the latter usually being wider and more sharply defined. For this reason the glume of the secondary floret is the one which has received most consideration although the primary glume is of considerable assistance also.

THE EFFECT OF ENVIRONMENT ON GLUME CHARACTERS

The degree to which glume characters may be affected by different environments has received as thorough a consideration as possible in connection with the present study. Obviously, to be of value, a classification must be useable no matter where the varieties concerned are grown. The American taxonomists recognized this fully and based their Key on a very thorough study of environmental influences. A further study of this question under Canadian conditions has been made by the Cereal Division and the results of this investigation to date are incorporated in the Key now under construction.

Reference has been made already to the response to environment of shape and density of head and to the care one must exercise in accepting these characters as distinguishing features.

MATERIAL AND METHODS

In 1924 seed of a number of wheat varieties under test at Ottawa was sent to the branch Farms for comparison in quadruplicated "rod-row plots." Before harvest minute examinations were made of the progeny at each point by the writer and the results duly recorded. In 1925 this study was continued but on a much more extensive scale. Actual measurements were made and recorded of such characters as width of shoulder and beak and length of beak. Five heads representing what appeared to be extremes regarding the characters concerned, were located within each plot and measured. Masurements to indicate "head density" also were made of these same heads whose shapes likewise were noted. Photos were taken of empty glumes taken from heads obtained first at our Ottawa

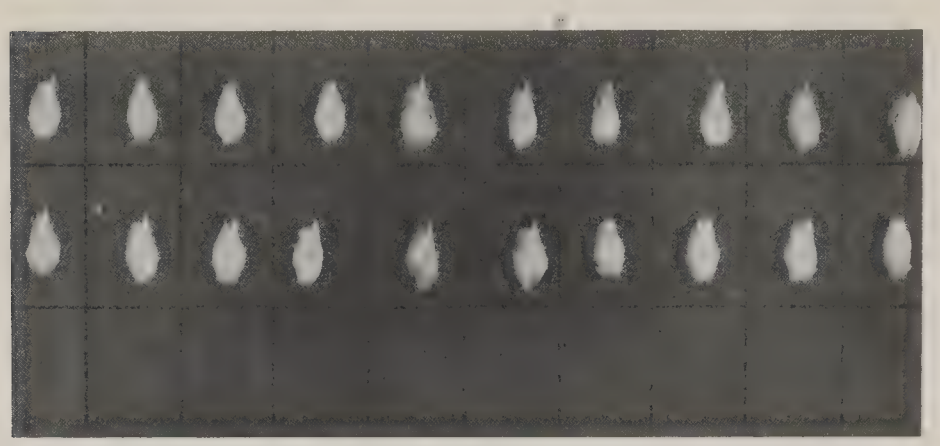

FIG. IX—Glumes of Marquis O.15. Bottom row from spikelets at seventh node from base. Top row from spikelets at eighth node from base.

Farm and again at the different branch Farms. In fig. IX are shown glumes from different heads of Marquis Ottawa 15 collected at Ottawa. The first row consists of glumes from the seventh node from the base of the spike while the second row represents glumes from the eight node. The pronounced tendency toward elevated shoulders in the upper row is apparent, a tendency which seems fairly characteristic in this variety. The shoulders in the case of the lower row, it will be noted, also show this tendency but to a lesser degree although under certain conditions the elevated type of shoulder may be decidedly pronounced.

In Fig. X are shown glumes taken from similarly located spikelets borne on heads of Marquis 0.15 but in this case the heads came from *widely separated* farms. The rather remarkable uniformity in the general shape of shoulder as well as in the shape and length of beak is noteworthy.

In fig. XI are shown glumes taken from the spikelet at the seventh node of heads of Kitchener obtained from different farms. This variety, as previously intimated, is sometimes confused with Marquis and sometimes with Early Red Fife or other types which appear to be closely related. Here again the relative uniformity in the general character of shoulder and beak of the several glumes, though grown at different places, is at once apparent.

In fig. XII glumes taken from heads of Early Red Fife obtained from different places are compared. As in the case of the two preceding varieties, the type of beak and shoulder peculiar to the variety is maintained fairly closely irrespective of locality in which the variety is grown.

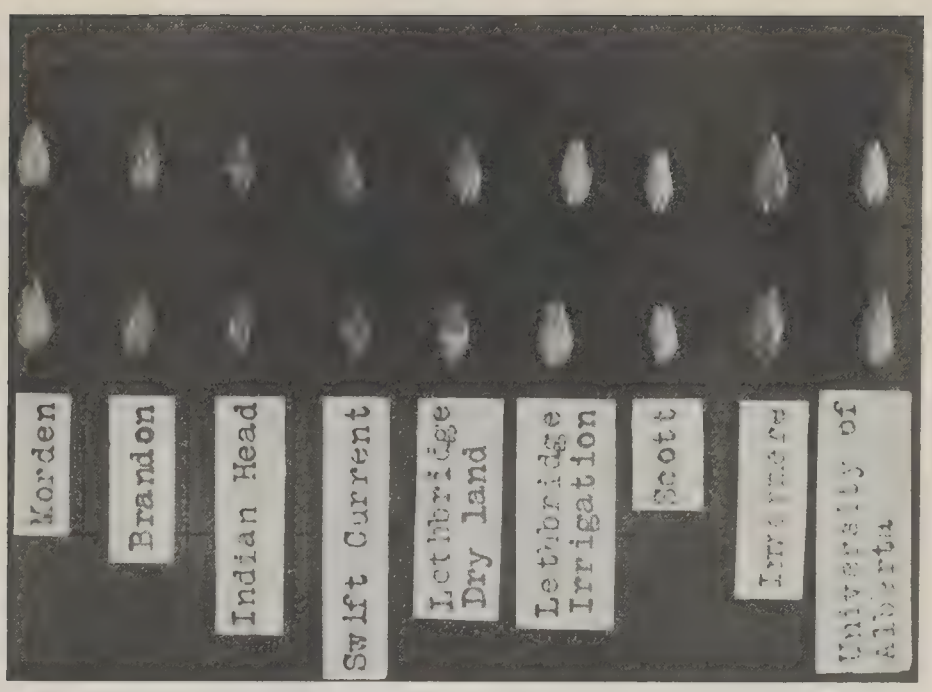

FIG. X—Glumes of Marquis O.15. From widely separated farms.

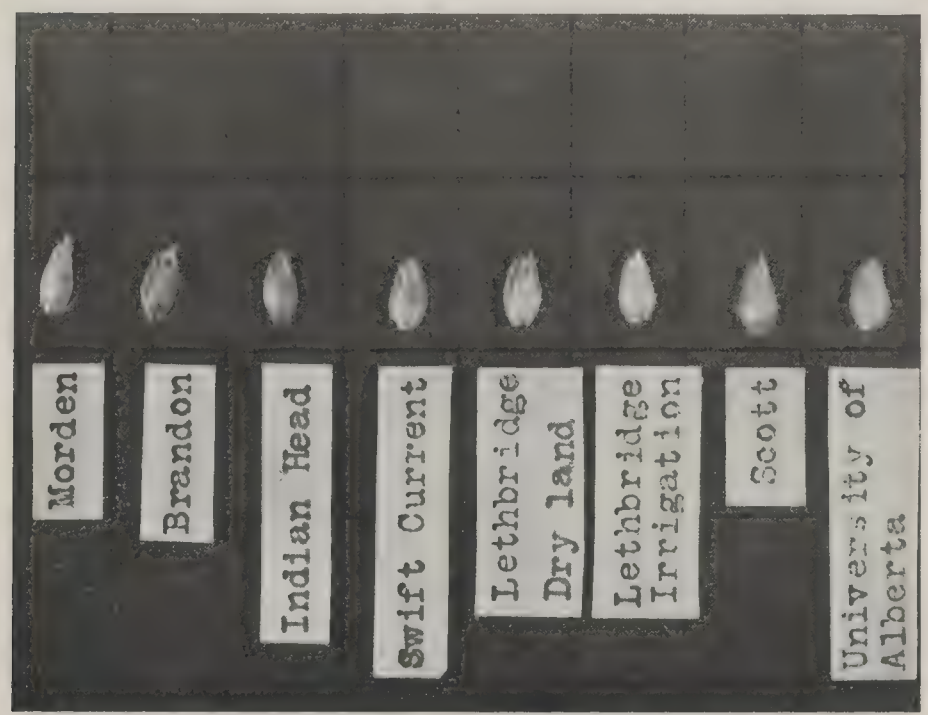

FIG. XI—Glumes of Kitchener. From widely separated farms.

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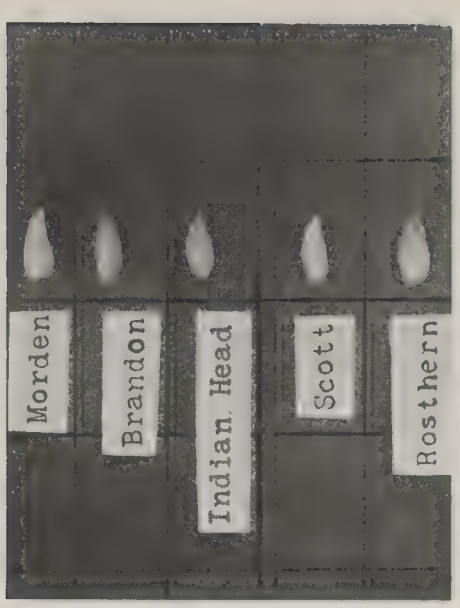

FIG. XII—Glumes of Early Red Fife from widely separated farms.

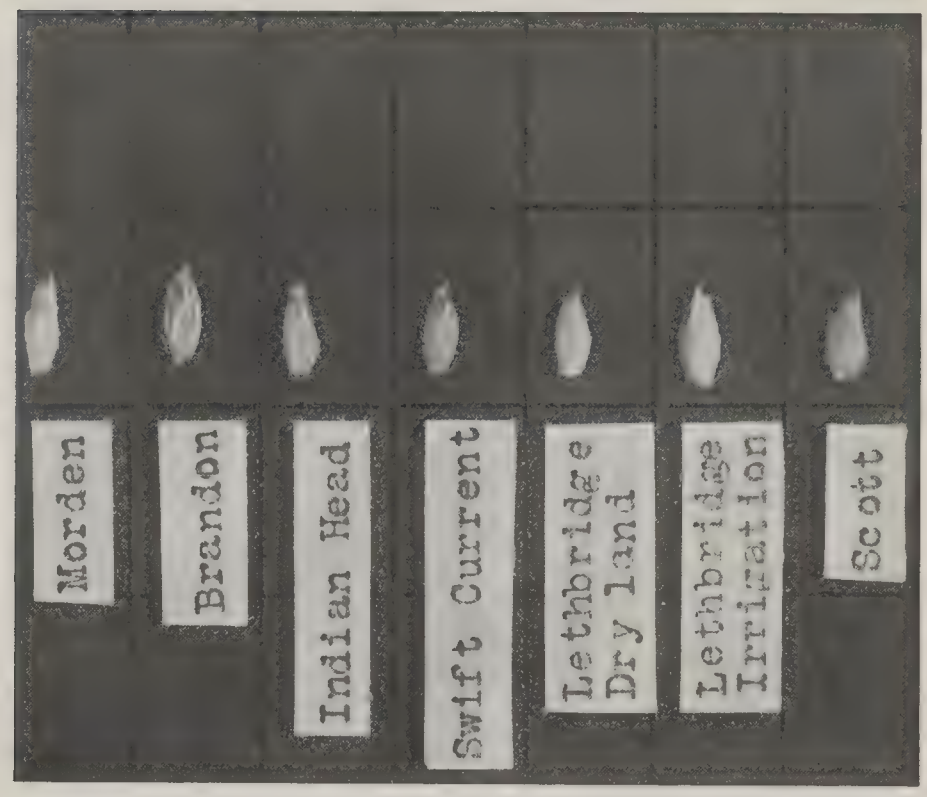

FIG. XIII—Glumes of Garnet. From widely separated farms.

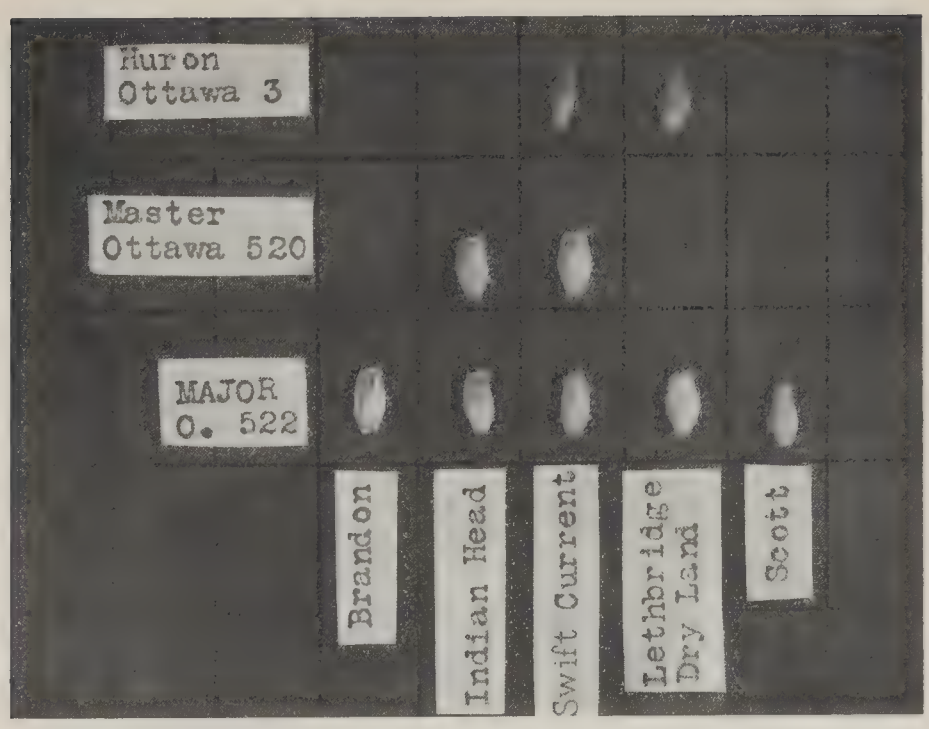

FIG. XIV—Glumes of Huron, Master and Major. From widely separated farms.

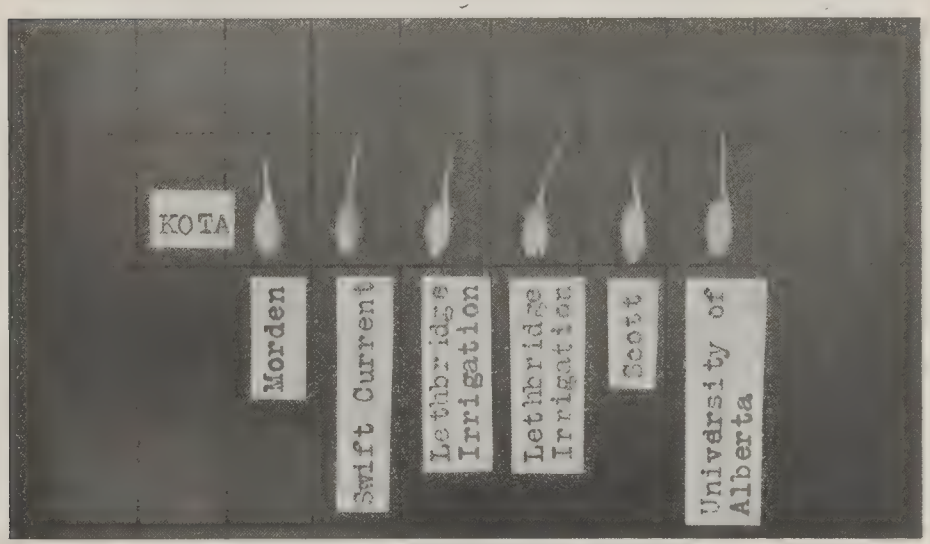

FIG. XV—Glumes of Kota. From widely separated farms.

At this point a comparison might be made to advantage of the glume characters of the above three varieties when grown under normal field conditions. In the case of Marquis the shoulders have a tendency to be elevated, while the mean length of beak is almost 1 m.m.; the latter is also quite acute. In Kitchener the shoulders are mostly square to oblique but the chief difference is found in the beak. This, in Kitchener is usually shorter and broader than in Marquis. The final decision as to which is which is provided by the structure of the upper quarter of the head.

In Early Red Fife the shoulders are usually more narrow and oblique while the beak is longer, more oblong in contour and normally rounded at the tip. Under certain conditions, however, we find these differences less pronounced.

Fig. XIII illustrates the very acute beak and narrow shoulder of the glumes of Garnet. In this variety the peculiarly elongated lemma is a distinct aid in distinguishing this from other sorts.

In fig. XIV are shown glumes of Major, Master and Huron. The wide shoulders and very short beaks of the two sister sorts, Major and Master, are in sharp contrast with the long sharp beak and narrow shoulder characteristic of Huron.

Fig. XV shows the glume characters of Kota with its distinctly long beak. The latter is one of the important features which distinguish this variety from Preston. The latter variety bears awns and white coloured glumes fairly similar to Kota, but the beaks of Preston are not elongated as in the former variety.

INVESTIGATION OF MARQUIS STOCKS

During the past season (1925) at our request, heads were picked by 167 growers of Marquis in Manitoba and Saskatchewan and sent to our Ottawa laboratory for special study. We asked for fifty heads from each man and received at least this many in practically all cases. Thus over eight thousand heads were received and minutely examined. Some of these lots were composed entirely of heads which conformed to what we considered the true Marquis type. Other lots included heads which differed in certain details from the standard we adopted for the genuine Marquis, but which we considered for the time being to be legitimate deviations from the " mean " of that type. Others again contained types which could not be included in the Marquis group at all. To be exact, 61 per cent were condemned outright, 29 per cent were unqualifiedly approved and 10 per cent were approved pending further study. For convenience we classified, described and numbered all of those different types which appeared fairly regularly. Types which did not belong to any of those described we grouped together under " miscellaneous " types:

The above types were described as follows:—

(a) *Marquis* (see fig. III).—Spike awnless except for short apical awns which latter are usually fairly pronounced, irregular in length and in position.

Spike fusiform in shape under all conditions, mid-dense under normal conditions, but under other conditions may be fairly lax or quite dense. Glumes, white and glabrous.

Shoulder of empty glume of secondary floret on seventh node from base of spike, square to slightly elevated under normal conditions. Under conditions which force an abnormal growth and more open head the shoulder of the glume is likely to be quite oblique, while under sub-normal conditions the shoulder may be decidedly elevated.

Beak terminating the Keel of the above glume always acute but fluctuating in length between .7 m.m. and 1 m.m. In the case of lax heads (those in which the first 10 internodes of the rachis occupy 55 m.m. or more in length) the beak has a distinct tendency to turn in, which tendency is not apparent under normal field conditions.

Fig. XVI—Head of Type Ia—Two views.

FIG. XVII—Head of Type Ib—Two views.

(b) *Type I.*—Head more oblong and thick than Marquis, with shortened internodes toward the tip. Terminal florets, usually two or three in number, well developed and usually fertile giving tip a more or less thickened appearance as a rule. The degree of this terminal development varied considerably. Tips which were distinctly well developed and which, as a result, were described as *clavate* we designated as Type Ia (fig. XVI). Where there was only a slight indication toward clavateness in the case of heads otherwise conforming to Type I we designated such heads as Type Ib (fig. XVII), while in the case of other heads of this type which were not thickened at the tip but which were otherwise identical with "a" and "b" we classed as Type Ic (fig. XVIII). The latter class was much the more common of all the aberrant types distinguished.

FIG. XVIII—Head of Type Ic—Two views.

The glume characters in the case of Types Ia, Ib and Ic were identical. They were distinguished from Marquis in having more oblique shoulders, glumes wider toward the base, heavier and broader beak with distinctly rounded tip. The glumes also were almost regularly lighter in colour when mature.

Heads similar to the above three types but which possessed glumes bearing more acute beaks we designated as Type Id (fig. XIX).

(c) *Type II.*—Heads resembling those of Marquis in all respects except in beak, which latter was distinctly shorter than in our so-called "Standard Marquis", we designated as Type IIb (fig. XX) although admitting freely the absence of sufficient data to justify our regarding it as anything but a fluctuating variation of true Marquis.

FIG. XIX—Head of Type Id—Two views.

FIG. XX Head of Type II—Two views.

(d) *Type III* (Common Red Fife—fig. IV).—Spike bearing short fine tip awns fairly similar to Marquis but usually more even in length and arrangement; oblong in shape, slightly denser than Marquis throughout but distinctly more dense toward the tip. Glumes glabrous and white. Glumes of primary florets narrower as a rule than in Marquis. Shoulder of glume of secondary floret usually quite oblique while that of the glume of the primary floret is almost wanting.

Beak acute to obtuse, shorter on the average than Marquis and slightly wider at the base.

(e) *Type IV*.—This type was described as resembling Marquis closely but bearing a more inturned beak than the latter. It is now quite clear that this type is only a slight variation which seems to occur only occasionally within Marquis as grown in the field and which is not transmitted.

(f) *Type V*.—Distinguished chiefly by its dense head and extremely short beak fig. XXI). In some cases the latter was almost wanting. This type appeared to be closely related to Type I.

Fig. XXI—Head of Type Va—Two views.

FIG. XXII—Head of Type VI—Two views.

(g) *Type VI*—(fig. XXII).—A slight deviation from Type III. Differing from the latter in having wider shoulders on the glumes of the primary florets.

(h) *Type VII*—(fig. XXIII).—Differing from Marquis in having sharply elevated shoulders, a slightly denser but thinner head and bearing spikelets which lie closer to the rachis. This type, as indicated later, is certainly distinct.

(i) Early Red Fife (see fig. II).—Spikes fairly long and usually bearing well developed tip awns; oblong in shape, relatively lax toward the base but distinctly dense toward the tip; under certain conditions quite clavate.

Glumes glabrous, white, and relatively long. Shoulder of glume of secondary floret distinctly oblique while that of primary floret is practically wanting.

Beak oblong and usually rounded at tip with a distinct tendency to turn in, especially in the case of the primary floret; 1 m.m. to 1.5 m.m. long.

Fig. XXIII—Head of Type VII—Two views.

It is interesting and significant, I think, that types similar to Early Red Fife and to those included under Type I were selected out of the common Red Fife as grown at Ottawa fifteen years ago. Neither of these types however have been found by us thus far within genuine Marquis 0.15 as grown at Ottawa or on our branch Farms. As a matter of fact none of these types were found by us in 76 out of the 167 lots above referred to, neither have we any evidence that they were ever present in the original Marquis sent out from the Central Farm.

The glume characters of these different types are illustrated in fig. XXIV and are well worth comparing.

FIG. XXIV—Glume characters of different types.

INVESTIGATION OF THE PROGENY OF ISOLATED TYPES

While we recognized the above forms as distinct at the time, we did not assume that they were all genetically distinct types but that some might be mere modifications of others. Our next problem then was to determine the types which might be included in the genuine Marquis group as well as to prove those which clearly did not belong to this group. To do this it was necessary to propagate the various types in sufficiently large numbers and, if possible, under controlled conditions. Ten kernels from each of 230 heads taken from lots coming from widely separated areas, accordingly were planted in the greenhouse last winter and the resulting progeny, only recently matured, has been subjected to a critical analysis. The kernels planted were carefully extracted from the parent heads without damaging the latter so that the progeny might be compared with the head from which it sprang in each case. Artificial light was used from dusk until midnight on part of the house designated as Section 1, while the remainder of the house, designated as Section 2, was left under normal conditions for most of the growing period. The effects of this treatment on the development of the heads in each case were remarkable, not only in demonstrating the influence of light itself, but in the extent to which the different conditions affected the development of the various small parts which go to make up the head. We were thus provided with material grown under conditions which forced two widely different types of growth both of which were quite abnormal.

Probably the most striking change effected was in the density of the head. In Section 1 of the greenhouse which had received the benefit of artificial light until midnight, the heads were uniformly more lax than were those of the plants

from which they sprung. In the case of the other section of the greenhouse not provided with artificial light, at least until the latter period of growth, the heads were decidedly more dense in all cases than were the parent heads.

The general shape of head in both cases also was altered to some extent by the degree of the development of the kernels. In the artificially illuminated section the kernels enjoyed an almost abnormal degree of development which forced the spikelets to assume a somewhat outstanding position in relation to the rachis, whereas, in the parent heads, the kernels were normally developed and the spikelets thus were *able* to lie much more closely to the rachis, giving the head a more compact but less vigorous appearance.

In Section 1 of the greenhouse the tip spikelets were not always well developed, due presumably to the reduction in the amount of water furnished the plants as these approached maturity. In spite of all these conditions we found that the general shape of the parent heads has been well maintained, as has also the general structure of the head with regard particularly to the tip spikelets and to the relative length of the internodes toward the tips. Thus parent heads belonging to what we had designated Type I, and which are characterized by shorter internodes toward the tip of the head and well developed multiple florets within the terminal spikelet, have transmitted to the progeny the same general characteristics, although in a more or less modified form. Similarly Marquis which is differently constructed toward the tip of the head reproduces its peculiar characteristics quite accurately. In other words Marquis in the greenhouse assumes a certain type of development characteristic of this type under these conditions, whereas Type I assumes a different sort of development. These differences were not quite so pronounced in Section 1 of the greenhouse containing plants which were forced to quick maturity, just as differences in types are not so pronounced in the field when lack of moisture hastens ripening unduly.

In Section 2 of the house the kernels were somewhat smaller while the head was unusually dense. The apical spikelet as well as the spikelets near the base of the spike were almost universally sterile thus often giving the spike a more or less elliptical appearance.

One of the most interesting observations recorded was the accuracy with which the essential *structure* or " skeleton " of the spike was transmitted. Thus heads of Type I, characterized by short internodes toward the tip and by having two or more well developed florets in the terminal spikelet, reproduced these characteristics quite definitely. The florets might or might not bear kernels in either case but the mechanism for their accommodation was there just the same. This is nicely illustrated in Fig. XXV showing a rather under-developed head of Type I on the extreme left and representative heads from 10 well developed plants of the progeny on the right. In this case the apical florets of the parent head were sterile, whereas, those of the progeny bore well developed kernels.

In the section of the house not receiving light during the early stages of growth, differences in maturity were more marked than in the case of Section 1. The differences between the different types were also more conspicuous.

With regard to shape of beaks developed under greenhouse conditions as compared with that of beaks of the parent heads grown under normal field conditions, we found that this had been modified to some extent, especially as regards the degree of acuteness. In the illuminated section of the house the plants practically all developed acute beaks, although in the case of Type I the beak of the parent was rounded (fig. XXVI). The modified tip of beak, however, was well maintained in the progeny of the different plants as was also the characteristic "dip" or depression in the Keel peculiar to this type.

FIG. XXV—Parent head on extreme left—(subnormal). Remaining heads represent the normally developed progeny of the parent head above referred to.

FIG. XXVI—In centre is shown the empty glume from parent head of Type I; the remaining 10 glumes are from 10 plants of the progeny as grown in greenhouse. Note modification in beaks of progeny, as well as constancy in shape of keel.

The relative lengths of the beaks in the case of the different types also were transmitted fairly accurately to the progeny.

The shape of shoulders of the progeny was modified considerably in Section 1 but comparatively little in Section 2.

The shape of glume, which has been an important aid in distinguishing varieties, has been transmitted fairly accurately from the parent heads to the progeny.

The information we have collected thus far in connection with this study would seem to indicate that in the construction of a classification which will enable one to distinguish varieties grown under all conceivable conditions the degree of deviation permissible must be distinctly liberal. First consideration must be given to the conditions under which the different types are grown. If grown under normal field conditions, and if developed normally, a form which is a distinct variety assumes its own characteristic development. If, on the other hand, these same types be grown under abnormal conditions one must be prepared to expect a modification in the character of those parts which are used for identification purposes.

In distinguishing varieties no single character is sufficient as a rule, to enable one to declare the variety to which a given form belongs; rather must one take into consideration, first, the general shape of the head, second, the structure of the upper part of the rachis as well as the tip spikelets, the density of head to some extent, the shape and size of beak, and the shape of shoulder of the outer glumes. The shape of the glume itself in some cases is a useful aid in this work, but all these points require to be balanced one against the other, all of which requires a good deal of experience especially in the case of types which to the casual observer may be more or less similar.

While it requires some practice undoubtedly before one can distinguish a given variety from other forms which do not belong to it, the ability to do this very thing is almost fundamental to successful breeding work and certainly to the successful growing of pure seed. This Association is to be congratulated in having succeeded as well as it has, considering all the circumstances, in having made so good a showing in this direction thus far. There is still much to do however, but I am sure that if we all do what we can in helping to maintain the high standard and purity of our approved types that this organization will continue to develop in a way which will be a credit to all concerned.

APPENDIX

Since presenting the foregoing paper (in June, 1926), further work has been done in connection with the above study, a brief report of which it is desired to include at this time.

In the spring of 1926 there were planted in the field in single rows, ten kernels from each of fourteen hundred heads specially chosen from the material above discussed. Some of this same material had been grown in the greenhouse where conditions admittedly were abnormal but which nevertheless permitted certain valuable observations to be recorded. It was considered desirable, however, to study this material under normal field conditions partly as a check on our greenhouse work and partly with a view to adding to our evidence as to the identity and constancy of the several types with which we had to deal.

The crop developed normally and ripened quite evenly thus providing excellent material for a study of this kind.

The progeny (head-row) from each parent head was harvested separately and subjected to a critical morphological study during the following winter. The parent head was compared with those of the progeny in each case, and careful measurements recorded. Where a given head row produced a "composite" progeny, actual counts were taken of the number of plants falling into the different types or groups. By following this plan we not only accumulated a mass of data as to the genetic composition and character of the various lines but we were able to study the inheritance of those small botanical characters which are concerned in determining the identity of different forms.

Space will not permit us to present in tabular form at this time, the results of our findings in connection with this study. Rather must we restrict ourselves to a general discussion as to how the different types reproduced those characters by which they are distinguished.

Probably the most striking discovery to be noted was that those parent types which did not conform to any regularly occuring type and which we had designated as "miscellaneous types", produced a variable progeny in the great majority of cases. A very good case is afforded in the results from the parent head desginated "449." This head had been labelled as "miscellaneous" for reasons explained above. It produced a progeny consisting of 23 heads which were divisable into the following groups:—

(*a*) Resembling parent—6 heads.
(*b*) Resembling Type II—2 heads.
(*c*) Resembling Type III—3 heads.
(*d*) Resembling Type VI—5 heads.
(*e*) "Miscellaneous Types" all different—7 heads.

Another typical illustration of the common behaviour of these so-called "miscellaneous types" is afforded in the results realized from No. 452 (miscellaneous). The progeny from this head consisted of the following:—

(*a*) Marquis Type—2 heads.
(*b*) Red Fife-like Types—11 heads.
(*c*) Miscellaneous (resembling the parent)—2 heads.

Another particularly interesting illustration of the behaviour of these "miscellaneous types" when propagated, is offered in the case of No. 455, misc. The parent head in this case possessed an outer glume bearing shoulders very

suggestive of those peculiar to Red Fife but with a beak somewhat resembling that of Type V. A study of the progeny from this head revealed the following main groups:—

(*a*) Common Red Fife-like heads—6.
(*b*) Heads resembling parent—2.
(*c*) Heads suggestive of Type V—6.

From these studies it seems reasonable to conclude that these types which do not readily fall into recognized groups or types have arisen, in most cases at least, as a result of natural crossing between genetically distinct forms growing together in an impure crop. This view gains support furthermore in the discovery that those strains of any given variety which were free, or relatively free, from other recognized types were singularly free from these "miscellaneous types." In other words, the purer the variety the fewer the chances for new forms to arise through natural crossing.

Still further evidence in support of the above statement is afforded in our studies of the progeny from Marquis types selected out of different assortments. Thus, Marquis-like types from badly mixed lots frequently produced a very variable progeny whereas typical Marquis heads from very pure strains of Marquis reproduced the true Marquis character with a high degree of accuracy. It is interesting to note in this connection that of all the different strains or "assortments" of Marquis investigated, Marquis 10B (Wheeler) and Marquis 0.15 (C.E.F. Ottawa) reproduced their distinguishing characters with greater regularity and precision than did most of the other so-called "strains of Marquis" which were specially studied.

The type designated as "Type No. 1", and which constituted a very large proportion of the mixtures found in certain lots of Marquis studied, has proven to be quite a distinct form. Its performance has been followed carefully through three generations—one in the greenhouse and two in the field—during which time it has reproduced its peculiar characteristics with extreme regularity. In those very few cases where this type produced a variable progeny a study of the latter seems to justify the conclusion that here again natural crossing was responsible for the situation.

The subdivision of Type I, namely, Type Ia, Type Ib, and Type Ic, have proven to be mere fluctuations within Type I. They are distinguished from each other on the basis of shape of head alone (clavate, sub-clavate or fusiform), but, as already pointed out, this character has proven variable and unreliable as a means of distinguishing types which are genetically different.

The true status of the type designated Type II is still somewhat obscure. As previously indicated (see page 18) this type differs from the standard Marquis type chiefly in having a distinctly shorter beak. In most cases this type produced a variable progeny in respect of length of beak although in some instances the parent type was reproduced quite truly. These latter cases appear to constitute a "short beaked selection" out of the original Marquis, while the former apparently were inconstant (heterozygous) forms resulting from natural crossing between Type II and some other type possessing beaks of greater length.

The type designated "Type V" (see page 20) has been carried through three generations and has proven quite distinctive in all cases.

The type designated "Type VI" appears to be an intermediate type between Type II and Common Red Fife and may have arisen as a result of a natural crossing between these two types. If this be the case cross-fertilization probably took place during comparatively recent years since the type in question produced a distinctly variable progeny in practically all cases.

NEW CONSTANT FORMS

Among the numerous types studied two distinct and rather promising types were found. These bore the initial numbers 370 and 375. The progeny was very uniform in each case while the heads and plants resembled their respective parents very closely. These types incidentally are being studied further with the hope that they may prove of some practical value.

COMPOSITION OF THE ORIGINAL MARQUIS

When Marquis was first distributed from the Central Farm at Ottawa fifteen, years or more ago, it was not absolutely true to a given type. Bearded heads were fairly frequent as were certain other types, most of which were more or less intermediate between the two parents. The prevailing type, however, was quite distinctive and dominant and certainly marked an enormous advance over any variety then available in Western Canada. Such forms as Type No. I and others which have occurred regularly in consignments of Marquis tracing back to certain growers, were not found in this original Marquis first sent out from Ottawa, as already pointed out. Further confirmation of this fact has been provided by recent studies of crops produced from seed of Marquis which traced back to the original distribution.

Thus in 1924 there was sown at Ottawa, seed of Marquis obtained direct from Dr. Seager Wheeler's sample exhibited at Wichita, Kansas, in 1914. An examination of the mature crop revealed only those bearded and intermediate forms which were peculiar to the original seed. Similarly, in 1924 there was sown at Ottawa seed obtained from a crop of Marquis grown in 1909 by Mr. E. B. Cay, of Beatty, Sask. Here again the original Marquis type of crop was reproduced.

In 1925 there was sown at the Central Farm, seed of Marquis obtained from a crop grown in Australia in 1918 the original seed of which had been sent to that country in 1911. An examination of the 1925 crop demonstrated again that the various aberrant types which have become mixed with certain lots of Marquis as grown in Western Canada during recent years were not present at the beginning, nor have they originated from Marquis itself.